UNIT 3:
CHEMICAL PROPERTIES

LEARNING OBJECTIVES

By the end of this section, participants will be able to:

- Recognize the three states of matter
- Define the following terms:
    - Vapor pressure
    - Flash point
    - Lower and upper explosive limits
    - Specific gravity
    - Solubility
    - Vapor density
    - Chemical reactivity
    - Ignition temperature
    - pH
- Describe how the pH scale can be used to assess the hazards of acids and bases
- Describe the following types of chemical reactions:
    - Oxidation
    - Explosion
    - Gas Compression
    - BLEVE

INSTRUCTOR NOTES

Purpose of Unit:

This unit reviews some basic chemistry every First Responder should know. The unit is intended to provide a basis for a practical, rather than theoretical, application of chemical principles.

Materials and Supplies:

Chalkboard or flip chart

For the vapor pressure demonstration:
- Water
- Acetone
- Two shallow aluminum pans

For the explosive limit demonstration:
- Two-gallon plastic jug, with a 2” hole in top and a 2” hole in the side
- Acetone
- Long-stemmed lighter

For specific gravity demonstration:
- Two clear glass or plastic beakers
- Water
- Liquid rinsing agent for automatic dishwashers (e.g. Jet Dry)
- Food coloring
- Vegetable oil

For the solubility demonstration:
- One clear glass or plastic beaker
- Water
- Food coloring
- Alcohol

For the vapor density demonstration:
- Block or pellets of dry ice
- Large plastic tub
- Candles (e.g. votive candles)
- Warm water

For the pH demonstration:
- pH papers
- A variety of common acidic and caustic products (vinegar, juice, lye)

Instructor Preparation:

Secure the materials and supplies listed above. Also, conduct all the demonstrations to make sure they serve your purpose and can be done safely.

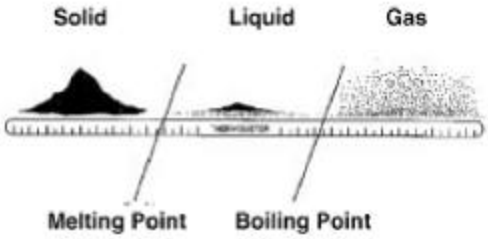
STATES OF MATTER

Introduction

Tell the students:

- **What they will learn in this section**
- **Approximately how long it will take**

All elements exist in nature in one of three states: **solid**, **liquid**, or **gas**. Substances can change from one state to another as changes occur in temperature or pressure, or both. A change in a material's state is likely to affect the degree of hazard posed by the material, as well as the tactics for controlling the situation. For example, a toxic substance may be more hazardous in the gaseous state than in the liquid state because it is easier to inhale as a gas and more difficult to control.



Key Points

- **All elements exist as a solid, liquid, or gas**
- **A chemical can become more dangerous as it changes from one state to another**
- **Changes in a chemical's state may affect your tactics as well**

Solids

A solid is a substance that retains a definite size and shape under normal conditions. When most solids melt, they change to liquid. The temperature at which this occurs is called the **melting point**. When solids change directly to gas, the process is called **sublimation**. Carbon dioxide (dry ice) is a well-known example of a solid that sublimates.

Liquids

Liquids are substances that flow easily and have a specific volume but no specific shape. The temperature at which a liquid freezes is called the **freezing point**. The temperature at which a liquid changes to a gas is its **boiling point**. At this temperature, which is unique to each liquid, bubbles of the liquid rise to the surface and enter the surrounding air. The boiling point of a liquid is related to its vapor pressure.

Gases

Activity

Tell the students to look up carbon dioxide, dimethylamine, and hydrogen fluoride in the NIOSH Pocket Guide. Briefly explain IDLH, then discuss which of the three is the most toxic.

A gas is a substance that expands or compresses readily and has no independent shape or volume. Gases may condense to form liquids; this change occurs when a gas is cooled to or below its boiling point. Substances that occur naturally as gases have low boiling points compared to solids and liquids.

To evaluate the hazard posed by a gas, you must know (or estimate) its concentration in air. Explosive limits are one way to evaluate the concentration of flammable gases and vapors. Concentration of gas can also be expressed in terms of percent, parts per million (ppm), and parts per billion (ppb). These terms are typically used in reference materials when listing the concentration of a gas or vapor that causes health effects. One part per million is equal to 1/1,000,000.

IDLH

(Immediately Dangerous to Life and Health) is a reference frequently mentioned in resource material. IDLH is the maximum level of exposure, without irreparable effects, within 30 minutes.

CHEMICAL PROPERTIES

Vapor Pressure

Activity

Demonstrate vapor pressure by pouring a small amount of water in one pan and an equal amount of acetone in another. Show the students how the acetone evaporates much more quickly than water.

Vapor pressure is a measure of the ability to evaporate, that is, to change from a liquid to a gas. (A liquid in the gas state is a vapor.) Vapor pressure is often measured in millimeters (mm) of mercury (Hg), but other units may be used. The higher the vapor pressure, the more likely a liquid is to evaporate. For example:

Material	Approximate Vapor Pressure at Room Temperature
Rock	0 mm Hg
Water	25 mm Hg
Acetone	250 mm Hg
Any gas	>760 mm Hg
Acetylene	2,500 mm Hg

Activity

Tell the students to look up methyl alcohol, chlorobenzene, and styrene in the NIOSH Pocket Guide. Discuss which chemical is most likely to ignite in air.

As temperature increases, the vapor pressure of a liquid increases. For example, look at the effect of temperature on the vapor pressure of water on the following chart.

Vapor Pressure of Water	Temperature of Water
25 mm Hg	72° F
93 mm Hg	122° F
760 mm Hg	212° F

If the temperature is high enough, the vapor pressure rises until it equals atmospheric pressure. At this point, the liquid boils and becomes vapor. Because liquids expand when they vaporize, the effect of temperature on a liquid's vapor pressure can be catastrophic if the liquid is in a closed vessel. If there is no mechanism for venting, the vapors generated as the liquid is heated will exert increasing amounts of pressure on the vessel, possibly leading to container failure.

Flash Point

Flammable liquids with high vapor pressures are generally more dangerous than those with low vapor pressures. This is because they more readily form ignitable mixtures in air and are more easily inhaled. **Flash point** is the temperature at which a liquid generates enough vapors to create an ignitable mixture near the surface of the liquid.

A **flammable liquid** is a liquid that has a flash point below 100°F (38°C). Liquids that have flash points of 100°F or more are classified as **combustible liquids.**

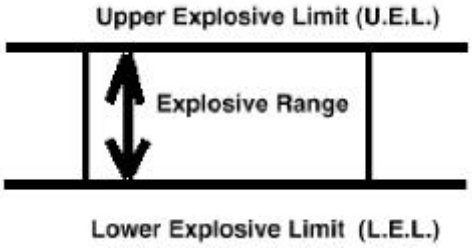
Explosive Limit

Explosive or **flammable limit** refers to the concentration of a flammable vapor or gas in air. Below the lower explosive limit (LEL), the mixture is "too lean" to ignite. This means that there are not enough flammable vapors in the air. Above the upper explosive limit (UEL), the mixture is "too rich" to ignite. That is, there is too little oxygen to support combustion. Between the LEL and UEL, the mixture is explosive or flammable. Remember that sources of electricity such as lights, motors, traffic, and static electricity can ignite mixtures between the LEL and UEL.

Flammable gases have an LEL of less than 13%, or a flammable range greater than 12%. Most flammable gases have LEL ranges of 3% to 6%.

Activity

Obtain a large (2-gallon) plastic jug. Cut a hole about 2" in diameter in the lid and one in the side of the jug. Demonstrate explosive limit by placing a few drops of acetone in the jug. Shake the jug, then insert a long-stemmed lighter through the side hole cut in the side of the jug. If the atmosphere doesn't ignite, add a few more drops and try lighting it again. Repeat until you reach the explosive limit and the mixture ignites. (CAUTION: Add the acetone *gradually* and be *extremely careful* when you conduct this demonstration.)

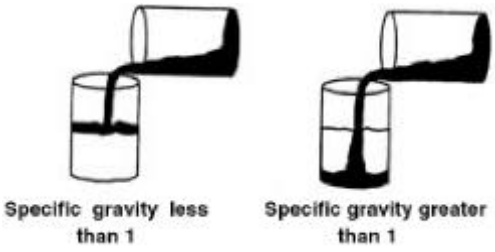


Activity

Fill two beakers about half-way with water. Add a few drops of food coloring to the vegetable oil, then add about 1/4 cup to the water in one beaker. The oil, with a specific gravity less than 1, will float on top of the water. Add about 1/4 cup of rinsing agent to the water in the second beaker. The rinsing agent will sink because its specific gravity is greater than 1.

Specific Gravity

Specific gravity is a concept used to measure the weight of solids and liquids in comparison to an equal volume of water. Water has a specific gravity of one. Solids and liquids that are heavier than an equal volume of water have specific gravities greater than one. Similarly, solids and liquids that are lighter than water have specific gravities less than one.



Specific gravity has no unit of measure. It is only a relative value (relative to water). The specific gravity of a substance indicates whether it will sink or float in water. This property can also determine your response activity (for example, the type of dam you build to control a liquid spill in water).

Solubility

Activity

Fill a beaker about half-way with water. Add a few drops of food color to about 1/4 cup of alcohol, then pour the alcohol into the water. The water and alcohol form a solution because alcohol is miscible.

Solubility refers to the degree that one substance mixes with another substance. The mixture is called a **solution**. The substance presenting greater amount is called the **solvent**. Water can be a solvent, though in common usage the term refers to petroleum-based chemicals. The substance present in lesser amount is called the **solute**. A solute may be a gas, a liquid, or a solid.

If a solute mixes completely in a solvent, it is said to be **miscible** with that solvent. For example, alcohols such as methyl, ethyl, and propyl alcohol are miscible with water. **Water miscible** means that the liquid is infinitely soluble in water. Regardless of the amount of methyl alcohol added to water, it will all mix. All other liquids (and all solids) are either very soluble, soluble, sparingly soluble, or insoluble. Some references may also list solubility data in terms of a percentage, indicating the weight of the material that will dissolve in a certain amount of water.

Activity

Demonstrate vapor density with a small block of dry ice. Place the ice in a tub on a raised surface and place lighted candles on the floor nearby. Add warm water to the dry ice and tip the pan. The vapors should flow to the floor and extinguish the candles.

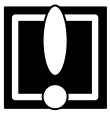
Vapor Density

The concept of **vapor density** is used to measure the weight of a gas compared to an equal volume of air. Air has a vapor density of one. Substances with vapor densities less than one are lighter than an equal volume of air and will rise in air. Those with vapor densities greater than one will sink in air, and often collect in low lying areas or close to the ground. This is important when sampling the air, identifying safe areas during an emergency, and predicting how a gas will spread.

There are a couple of shortcuts in determining whether a gas or vapor has a vapor density less than air. One method is to use the **molecular weight** of the chemical. The molecular weight is the mass that is assigned to atoms or molecules that make up a chemical. This unit may be found in references such as the NIOSH Pocket Guide to Chemical Hazards. Vapors and gases with molecular weights greater than 29 (the molecular weight of air) tend to sink in air. Vapors of flammable liquids also tend to sink in air. (Flammable gases may rise or sink, depending on the gas; for example, propane sinks, and methane rises.)

Chemical Reactivity

Key Points



The speed of a chemical reaction depends on:

- **Temperature**
- **Concentration**
- **Pressure**
- **Catalysts**

Chemical reactions result when two or more substances combine to form new chemicals and energy is absorbed or released. Polymerization, combustion, and ionization are examples of chemical reactions. The rate at which a chemical reaction occurs depends on a number of factors, including:

- **Temperature**—increasing temperature usually speeds reactions
- **Concentration**—increasing the concentrations of the reacting materials usually increases the rate of reaction
- **Pressure**—increasing pressure, especially on reacting gases and vapors, may speed reactions, though this is not always true
- **Presence of catalysts**—a catalyst is a substance that increases the rate of chemical reactions, but is not changed by the reaction

Activity

Ask the students to list other water-reactive or pyrophoric materials. Allow them to use their reference books to look up examples.

In addition to the factors listed above, the physical and chemical properties of the reactive materials can influence the reaction. For example, gases and vapors react more readily than liquids and solids; and highly reactive materials can spontaneously explode or ignite when exposed to another substance.
Some materials react when exposed to water. For example, sodium metal is extremely **water-reactive** and may explode when in contact with water. It is stored dry or in mineral oil or kerosene. **Air reactive** materials react when exposed to air. White and yellow phosphorous spontaneously ignite in air; a related term, pyrophoric, is used to describe a material (liquid or solid) that spontaneously ignites in air at or below 130°F.

Ignition Temperature

Key Points

The ignition temperature is the temperature at which a material burns.

References may list the **ignition temperature** of a chemical (also called the auto-ignition temperature). This is the temperature at which a material starts to burn without a flame or other ignition source present. At this temperature, gases or vapors are consumed in fire as rapidly as they are formed, and the material continues self-sustained combustion. Many flammable solids have ignition temperatures greater than 400°F, much higher than flash points of flammable liquids. One notable exception is phosphorus (white or yellow), with an ignition temperature of 86°F.

pH

Activity

Demonstrate pH with several acidic and caustic products such as vinegar, orange juice, and lye. Tell the students to guess the pH, then test each liquid with a pH strip.

The pH scale is a reference scale indicating the acidity or alkalinity of materials. The scale ranges from 0 to 14, with 7 considered neutral. Values lower than 7 indicate increasing acidity, while those higher than 7 indicate increasing alkalinity. The pH scale is a logarithmic scale, with 7 at the center of the scale. This means that the difference in acidity from pH 6 to pH 7 is small, while the difference from pH 3 to pH 4 is greater, and the difference in acidity between pH 1 and pH 2 is very great. When dealing with acids and bases, it is also important to obtain information about the **concentration** of the acid or base. Concentration indicates the percentage of the material in water. Both acids and alkalis can cause injury. Materials with a very low or very high pH are the most hazardous, and any highly concentrated acids or bases should be carefully assessed before action is taken. Caustics are particularly dangerous because the chemical seeks out the acids in the body.

Other Chemical Reactions

Other chemical reactions may affect the way you respond to an incident involving a hazardous material.

Oxidation

Activity

On the flip chart or chalkboard list oxidization, explosion and gas compression and ask the students to name common chemicals that can:

- **Oxidize or promote oxidation**
- **Detonate or explode**
- **Be compressed**

Oxidation is a chemical reaction that enables a substance to burn. In a fire, the presence of an oxidizer will make the fire burn hotter and faster, and may cause explosions. Oxygen is a powerful oxidizer, but by itself it is non-flammable. When added to other materials (even non-flammable protective clothing) it dramatically accelerates combustion.

Explosions

Explosions are chemical reactions that suddenly release a tremendous amount of energy. Explosions can be loosely categorized according to reaction time. High explosives react quickly — within millionths of a second — while low explosives react more slowly. High explosives (such as dynamite) **detonate**; that is, they create and almost instantaneously release gas. Low explosives (such as black powder) **deflagrate** in that they create gas a little more slowly.

Gas Compression

Gas compression can also lead to chemical reactions. Compared with other states of matter, gases are the least dense. They can be compressed by increasing pressure or decreasing temperature to force the gas into a smaller volume. Certain gases are classified as cryogenic because of their low temperatures and extremely low boiling points.

Unlike other compressed gases, you must consider the extreme coldness of a cryogenic gas during a fire. Cryogenic containers always carry safety relief devices. Applying water may freeze these devices and cause the container to rupture.

A hazard common to all compressed gases is the potential for the expansion of the gas when it is warmed or no longer under pressure. Containers may fail, releasing large amounts of the gas. The expansion ratio refers to the comparison of a volume of the gas to its liquefied form. For example, liquefied natural gas (LNG) has an expansion ratio of 600 to 1. This means that one cubic foot of LNG will expand to 600 cubic feet when warmed or no longer under pressure.

BLEVE

Flammable gases that are transported or stored in their liquefied form are particularly hazardous because there is the potential for a **boiling liquid expanding vapor explosion (BLEVE).** This is the term for an uncontrolled fire and explosion of vapor as it escapes from a ruptured container of liquefied flammable gas. A BLEVE occurs when a container is exposed to fire. The liquid inside begins to boil and vaporize. The vapor is vented from the relief valve and the level of liquid begins to drop. As this happens, the flames impinge on the vapor space of the tank. Heat and pressure build, and the container weakens and ruptures, resulting in an explosion.

Conclusion

Briefly review the key points covered in this section.

UNIT 3
APPENDIX

MSDS Exercise

Material Safety Data Sheets (MSDSs) contain standard information about hazardous chemicals at fixed locations. They are published by chemical manufacturers. The format of an MSDS, including the order in which information appears, may be different for each chemical. It may also vary among manufacturers of the same chemical. Review the three MSDSs on the following pages for methyl ethyl ketone, carbon disulfide, and muriatic acid. Then answer the questions below.

Which of these chemicals is/are flammable?

Methyl ethyl ketone (LEL 1.8%)
Carbon disulfide (evaporates readily; LEL 1.3%)

Which is/are required to have a Flammable Liquid and Poison label?

Carbon disulfide
(Note that there is no transportation data for muriatic acid.)

Which will evaporate the fastest at room temperature?

Carbon disulfide
(Note that although no reference temperature is given for the vapor pressure of methyl ethyl ketone, it is assumed to be 68-70°).

Which is the most toxic?

These chemicals are difficult to compare in toxicity. The MSDS for methyl ethyl ketone indicates the TLV/TWA as 200ppm, the STEL as 300ppm, and the PEL as 200ppm. Lethal doses are given in kilograms. The MSDS for carbon disulfide lists only the TLV, at 10ppm to the skin. The MSDS for muriatic acid lists the OSHA PEL at 5ppm and "Other Recommended Limit" as 7ppm. As a general rule, however, you can assume that the lower the ppm, the more toxic the chemical.

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: METHYL ETHYL KETONE
FORMULA: CH3COCH2CH3
FORMULA WT: 72.11
CASE NO.: 78-93-3
NIOSH/RTECS NO.: EL6475000
COMMON SYNONYMS: 2-BUTANONE; MEK; ETHYL METHYL KETONE; METHYLACETONE
PRODUCT CODES: 9214,9323,9211,5385,9319,Q531
EFFECTIVE: 08/27/86
REVISION #02

PRECAUTIONARY LABELING
BAKER SAF-T-DATA(TM) SYSTEM

HEALTH - 2 MODERATE
FLAMMABILITY - 3 SEVERE (FLAMMABLE)
REACTIVITY - 2 MODERATE
CONTACT - 1 SLIGHT

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

SAFETY GLASSES; LAB COAT; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER

PRECAUTIONARY LABEL STATEMENTS

WARNING
EXTREMELY FLAMMABLE
CAUSES IRRITATION
HARMFUL IF INHALED

KEEP AWAY FROM HEAT, SPARKS, FLAME.
AVOID BREATHING VAPOR. KEEP IN TIGHTLY CLOSED CONTAINER. USE WITH ADEQUATE VENTILATION. WASH THOROUGHLY AFTER HANDLING. IN CASE OF FIRE, USE ALCOHOL FOAM, DRY CHEMICAL, CARBON DIOXIDE - WATER MAY BE INEFFECTIVE. FLUSH SPILL AREA WITH WATER SPRAY.

SAF-T-DATA(TM) STORAGE COLOR CODE: RED (FLAMMABLE)

2 - HAZARDOUS COMPONENTS

COMPONENT	%	CASE NO.
METHYL ETHYL KETONE	90-100	78-93-3

3 - PHYSICAL DATA

BOILING POINT: 80 C (176 F) VAPOR PRESSURE(MM HG): 78

MELTING POINT: -87 C (-125 F) VAPOR DENSITY(AIR=1): 2.5

SPECIFIC GRAVITY: (H2O=1) 0.81 EVAPORATION RATE: (BUTYL ACETATE=1) 5.7

SOLUBILITY(H2O): APPRECIABLE (MORE THAN 10 %) % VOLATILE BY VOLUME: 100

APPEARANCE & ODOR: CLEAR COLORLESS, LIQUID WITH ACETONE-LIKE ODOR.

4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP -7 C (20 F) NFPA 704M RATING: 1-3-0

FLAMMABLE LIMITS: UPPER - 11.4 % LOWER - 1.8 %

FIRE EXTINGUISHING MEDIA
USE ALCOHOL FOAM, DRY CHEMICAL OR CARBON DIOXIDE. (WATER MAY BE INEFFECTIVE.)

SPECIAL FIRE-FIGHTING PROCEDURES
FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE. MOVE CONTAINERS FROM FIRE AREA IF IT CAN BE DONE WITHOUT RISK. USE WATER TO KEEP FIRE-EXPOSED CONTAINERS COOL.

UNUSUAL FIRE & EXPLOSION HAZARDS
VAPORS MAY FLOW ALONG SURFACES TO DISTANT IGNITION SOURCES AND FLASH BACK. CLOSED CONTAINERS EXPOSED TO HEAT MAY EXPLODE. CONTACT WITH STRONG OXIDIZERS MAY CAUSE FIRE.

TOXIC GASES PRODUCED
CARBON MONOXIDE, CARBON DIOXIDE

5 - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE (TLV/TWA): 590 MG/M3 (200 PPM)

SHORT-TERM EXPOSURE LIMIT (STEL): 885 MG/M3 (300 PPM)

PERMISSIBLE EXPOSURE LIMIT (PEL): 590 MG/M3 (200 PPM)

TOXICITY: LD50 (ORAL-RAT)(MG/KG) - 2737
LD50 (IPR-MOUSE)(MG/KG) - 616
LD50 (SKN-RABBIT) (G/KG) - 13

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE
INHALATION OF VAPORS MAY CAUSE HEADACHE, NAUSEA, VOMITING, DIZZINESS, DROWSINESS, IRRITATION OF RESPIRATORY TRACT, AND LOSS OF CONSCIOUSNESS.
CONTACT WITH SKIN OR EYES MAY CAUSE IRRITATION.
PROLONGED EXPOSURE MAY CAUSE DERMATITIS.
LIQUID MAY CAUSE PERMANENT EYE DAMAGE.
INGESTION MAY CAUSE NAUSEA, VOMITING, HEADACHES, DIZZINESS, GASTROINTESTINAL IRRITATION.

TARGET ORGANS
NASAL SEPTUM, LUNGS

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE
NONE IDENTIFIED

ROUTES OF ENTRY
INHALATION, INGESTION, EYE CONTACT, SKIN CONTACT

EMERGENCY AND FIRST AID PROCEDURES
CALL A PHYSICIAN.
IF SWALLOWED, DO NOT INDUCE VOMITING.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. FLUSH SKIN WITH WATER.

6 - REACTIVITY DATA

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: HEAT, FLAME, OTHER SOURCES OF IGNITION

INCOMPATIBLES: STRONG OXIDIZING AGENTS, STRONG BASES, CAUSTICS, MINERAL ACIDS, AMINES AND AMMONIA, HALOGENS

DECOMPOSITION PRODUCTS: CARBON MONOXIDE, CARBON DIOXIDE

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING. SHUT OFF IGNITION SOURCES; NO FLARES, SMOKING OR FLAMES IN AREA. STOP LEAK IF YOU CAN DO SO WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. TAKE UP WITH SAND OR OTHER NON-COMBUSTIBLE ABSORBENT MATERIAL AND PLACE INTO CONTAINER FOR LATER DISPOSAL. FLUSH AREA WITH WATER.

J. T. BAKER SOLUSORB(R) SOLVENT ADSORBENT IS RECOMMENDED FOR SPILLS OF THIS PRODUCT.

DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

EPA HAZARDOUS WASTE NUMBER: U159 (TOXIC WASTE)

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLV REQUIREMENTS.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP TO 1000 PPM, A CHEMICAL CARTRIDGE RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE IS RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED BREATHING APPARATUS IS RECOMMENDED.

EYE/SKIN PROTECTION: SAFETY GOGGLES, UNIFORM, APRON, RUBBER GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: RED (FLAMMABLE)

SPECIAL PRECAUTIONS
BOND AND GROUND CONTAINERS WHEN TRANSFERRING LIQUID. KEEP CONTAINER TIGHTLY CLOSED. STORE IN A COOL, DRY, WELL-VENTILATED, FLAMMABLE LIQUID STORAGE AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	METHYL ETHYL KETONE
HAZARD CLASS	FLAMMABLE LIQUID
UN/NA	UN1193
LABELS	FLAMMABLE LIQUID
REPORTABLE QUANTITY	5000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	METHYL ETHYL KETONE
HAZARD CLASS	3.2
UN/NA	UN1193
LABELS	FLAMMABLE LIQUID

MATERIAL SAFETY DATA SHEET
FSC: 6810
NIIN: 012090692
Manufacturer's CAGE: 62910
Part No. Indicator: A
Part Number/Trade Name: CARBON DISULFIDE,4351-030

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General Information

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Item Name: CARBON DISULFIDE, ANALYZED REAGENT
Company's Name: MALLINCKRODT INC., SCIENCE PRODUCTS DIVISION
Company's Street: PARIS BYPASS
Company's P. O. Box: M
Company's City: PARIS
Company's State: KY
Company's Country: US
Company's Zip Code: 40361
Company's Emerg Ph #: 314-982-5000
Company's Info Ph #: 800-354-2050
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 06APR89
Safety Data Review Date: 08FEB95
Supply Item Manager: KX
MSDS Preparer's Name: UNKNOWN
MSDS Serial Number: BGQQG
Specification Number: NONE
Spec Type, Grade, Class: NONE
Hazard Characteristic Code: F5
Unit Of Issue: BT
Unit Of Issue Container Qty: 1 PT
Type Of Container: BOTTLE
Net Unit Weight: 1.3 LBS
NRC/State License Number: NOT RELEVANT

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: CARBON DISULFIDE (SARA 302/313) (CERCLA)
Ingredient Sequence Number: 01
Percent: 100
NIOSH (RTECS) Number: FF6650000
CAS Number: 75-15-0
OSHA PEL: 20 PPM
ACGIH TLV: S, 10 PPM; 9495
Other Recommended Limit: NOT RECOMMENDED

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Physical/Chemical Characteristics

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Appearance And Odor: CLEAR COLORLESS LIQUID, ODORLESS (PURE)/STRONG GARLIC-LIKE ODOR
Boiling Point: 115F,46C
Melting Point: -148F,-100C
Vapor Pressure (MM Hg/70 F): 300 @ 68F
Vapor Density (Air=1): 2.6

Specific Gravity: 1.26
Decomposition Temperature: UNKNOWN
Evaporation Rate And Ref: 22.6 (N-BUTYL ACETATE=1)
Solubility In Water: 0.2 %
Percent Volatiles By Volume: 100
Viscosity: UNKNOWN
Corrosion Rate (IPY): UNKNOWN
Autoignition Temperature: 194F
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Fire and Explosion Hazard Data
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Flash Point: -22F,-30C
Lower Explosive Limit: 1.3
Upper Explosive Limit: 50
Extinguishing Media: USE CARBON DIOXIDE, SAND, FOAM/DRY CHEMICAL. WATER SPRAY MAY BE USED TO KEEP FIRE EXPOSED CONTAINERS COOL.
Special Fire Fighting Proc: WEAR FULL PROTECTIVE CLOTHING AND NIOSH-APPROVED SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN THE POSITIVE PRESSURE MODE.
Unusual Fire And Expl Hazards: VAPOR IS HEAVIER THAN AIR AND CAN TRAVEL CONSIDERABLE DISTANCE TO A SOURCE OF IGNITION AND FLASH BACK. CONTAINERS MAY RUPTURE DUE TO VAPOR PRESSURE BUILDUP.
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Reactivity Data
==========
Stability: YES
Cond To Avoid (Stability): HEAT, IGNITION SOURCES, SPARKS, STATIC ELECTRICITY, HOT SURFACES, LIGHT
Materials To Avoid: STRONG OXIDIZING AGENTS, CHEMICALLY ACTIVE METALS (POTASSIUM, ZINC), AZIDES, ORGANIC AMINES
Hazardous Decomp Products: CARBON MONOXIDE, CARBON DIOXIDE, OXIDES OF SULFUR
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT
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Health Hazard Data
==========
LD50-LC50 Mixture: TLV 10 PPM (SKIN)
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: TARGET ORGANS: EYES, SKIN, CNS, LIVER, KIDNEYS, RESPIRATORY & GI TRACTS. ACUTE- TOXIC. MAY BE FATAL IF SWALLOWED OR INHALED. HARMFUL IF ABSORBED THROUGH SKIN. REPRODUCTIVE HAZARD. A POTENTIAL NEUROTOXIN. EYE CONTACT MAY CAUSE SEVERE PAIN. INHALATION CAUSES CNS DEPRESSION. CHRONIC- LIVER, RENAL & REPRODUCTIVE DISORDERS.
CARCINOGENICITY - NTP: NO
CARCINOGENICITY - IARC: NO
CARCINOGENICITY - OSHA: NO
Explanation CARCINOGENICITY: NONE
Signs/Symptoms Of Overexp: HEADACHE, DIZZINESS, FATIGUE, GARLIC BREATH, NAUSEA, VOMITING, ABDOMINAL PAIN, UNCONSCIOUSNESS, DEATH, CONVULSION; REDDENING, BURNING, CRACKING AND PEELING OF SKIN; SEVERE EYE PAIN AND BLURRED VISION
Med Cond Aggravated By Exp: INDIVIDUALS WITH PRE-EXISTING DISEASES OF THE EYE, SKIN, RESPIRATORY TRACT, LIVER, KIDNEYS, CNS MAY HAVE INCREASED SUSCEPTIBILITY TO THE TOXICITY OF EXCESSIVE EXPOSURES. IMMEDIATELY FLUSH WITH WATER FOR 15 MINUTES. HOLD EYELIDS OPEN. WIPE OFF EXCESS FROM SKIN BEFORE WASHING. INHALED: REMOVE

TO FRESH AIR. PROVIDE CPR/OXYGEN IF NEEDED. ORAL: IF CONSCIOUS, INDUCE VOMITING IMMEDIATELY BY GIVING TWO GLASSES OF WATER AND STICKING FINGER DOWN THROAT. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

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Precautions for Safe Handling and Use

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Steps If Matl Released/Spill: WEAR PROTECTIVE EQUIPMENT. VENTILATE AREA. REMOVE IGNITION SOURCES. KEEP OUT OF SEWER. ABSORB SMALL SPILL WITH PAPER TOWELS. EVAPORATE UNDER HOOD & BURN PAPER IN SUITABLE PLACE. USE SAND FOR LARGE SPILLS. TRANSFER TO PROPER CONTAINER FOR DISPOSAL.
Neutralizing Agent: NOT RELEVANT
Waste Disposal Method: ATOMIZE IN A RCRA APPROVED COMBUSTION CHAMBER OR DISPOSE OF AS HAZARDOUS WASTE IN A RCRA APPROVED FACILITY. DO NOT FLUSH TO SEWER. ENSURE COMPLIANCE WITH FEDERAL, STATE & LOCAL LAWS. REPORTABLE QTY (RQ) (CWA/CERCLA):5000LB
Precautions-Handling/Storing: STORE IN COOL, DRY, WELL-VENTILATED AREA, AWAY FROM IGNITION SOURCES & INCOMPATIBLE MATERIALS. OUTSIDE STORAGE PREFERRED.
Other Precautions: POISON AND FLAMMABLE. EMPTY CONTAINERS RETAIN RESIDUE AND CAN BE DANGEROUS. DO NOT CUT, WELD, SOLDER OR DRILL ON OR NEAR CONTAINER. AVOID BREATHING VAPORS. DO NOT GET IN EYES, SKIN OR CLOTHING. DO NOT SMOKE. KEEP OUT OF REACH OF CHILDREN.

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Control Measures

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Respiratory Protection: IF TLV IS EXCEEDED OR FOR SYMPTOMS OF OVER EXPOSURE, WEAR NIOSH-APPROVED SUPPLIED AIR-RESPIRATOR OR A NIOSH-APPROVED POSITIVE-PRESSURE SELF-CONTAINED BREATHING APPARATUS.
Ventilation: MECHANICAL (GENERAL AND/OR LOCAL EXHAUST, EXPLOSION-PROOF) VENTILATION TO MAINTAIN EXPOSURE BELOW TLV(S).
Protective Gloves: PVA
Eye Protection: GOGGLES AND/OR FULL FACE SHIELD
Other Protective Equipment: FULL PROTECTIVE CLOTHING, SAFETY SHOWER, EYE WASH STATION, BOOTS, LAB COAT. DO NOT WEAR CONTACT LENSES.
Work Hygienic Practices: OBSERVE GOOD INDUSTRIAL HYGIENE PRACTICES AND RECOMMENDED PROCEDURES. WASH THOROUGHLY BEFORE EATING, DRINKING/SMOKING.

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Transportation Data

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Trans Data Review Date: 95039
DOT PSN Code: CVR
DOT Proper Shipping Name: CARBON DISULFIDE
DOT Class: 3
DOT ID Number: UN1131
DOT Pack Group: I
DOT Label: FLAMMABLE LIQUID, POISON
IMO PSN Code: DOT
IMO Proper Shipping Name: CARBON DISULPHIDE
IMO Regulations Page Number: SEE 3109
IMO UN Number: 1131
IMO UN Class: 3.1
IMO Subsidiary Risk Label: TOXIC
IATA PSN Code: FIQ
IATA UN ID Number: 1131
IATA UN Class: 3
IATA Subsidiary Risk Class: 6.1
AFI PSN Code: ZZY

AFI Prop. Shipping Name: FORBIDDEN BY THIS MODE OF TRANSPORTATION
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Disposal Data
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Disposal Data Review Date: 88270
Rec # For This Disp Entry: 01
Tot Disp Entries Per NSN: 001
Landfill Ban Item: YES
Disposal Supplemental Data: MSDS FM MFR DATED 12 JULY 85 & CONFORMS TO OSHA HAZ COMM STD IN CASE OF ACCIDENTAL EXPOSURE OR DISCHARGE, CONSULT HEALTH AND SAFETY FILE FOR PRECAUTIONS.
1st EPA Haz West Code New: P022
1st EPA Haz West Name New: CARBON DISULFIDE; CARBON BISULFIDE
1st EPA Haz Wst Char New: ACUTELY TOXIC (H)
1st EPA Acute Hazard New: YES
2nd EPA Haz Wst Code New: D001
2nd EPA Haz Wst Name New: IGNITIBLE
2nd EPA Haz Wst Char New: IGNITABILITY
2nd EPA Acute Hazard New: NO
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Label Data
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Label Required: YES
Technical Review Date: 08FEB95
MFR Label Number: UNKNOWN
Label Status: F
Common Name: CARBON DISULFIDE,4351-030
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Severe: X
Fire Hazard-Severe: X
Reactivity Hazard-None: X
Special Hazard Precautions: TARGET ORGANS: EYES, SKIN, CNS, LIVER, KIDNEYS, RESPIRATORY & GI TRACTS. ACUTE- TOXIC. MAY BE FATAL IF SWALLOWED/INHALED. HARMFUL IF ABSORBED THROUGH SKIN. EYE CONTACT MAY CAUSE SEVERE PAIN. INHALATION CAUSES CNS DEPRESSION. CHRONIC- LIVER, RENAL & REPRODUCTIVE DISORDERS. STORE IN COOL, WELL-VENTILATED AREA, AWAY FROM IGNITION SOURCES & INCOMPATIBLES. USE SAND TO REMOVE SPILL. FIRST AID- GET IMMEDIATE MEDICAL ATTENTION. EYE/SKIN: IMMEDIATELY FLUSH WITH WATER FOR 15 MINUTES. HOLD EYELIDS OPEN. INHALED: REMOVE TO FRESH AIR. PROVIDE CPR/OXYGEN IF NEEDED. ORAL: IF CONSCIOUS, INDUCE VOMITING BY GIVING TWO GLASSES OF WATER & STICKING FINGER DOWN THROAT.
Protect Eye: Y
Protect Skin: Y
Label Name: MALLINCKRODT INC.,SCIENCE PRODUCTS DIVISION
Label Street: PARIS BYPASS
Label P.O. Box: M
Label City: PARIS
Label State: KY
Label Zip Code: 40361
Label Country: US
Label Emergency Number: 314-982-5000

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T & R CHEMICALS — MURIATIC ACID - ACID
MATERIAL SAFETY DATA SHEET
FSC: 6810
NIIN: 00F032922
Manufacturer's CAGE: TRCHE
Part No. Indicator: A
Part Number/Trade Name: MURIATIC ACID
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General Information
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Item Name: ACID
Company's Name: T & R CHEMICALS, INC
Company's Street: 700 CELUM ROAD
Company's P. O. Box: 330
Company's City: CLINT
Company's State: TX
Company's Country: US
Company's Zip Code: 79836
Company's Emerg Ph #: 915-851-2761
Company's Info Ph #: 915-851-2761
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 27JAN89
Safety Data Review Date: 14FEB94
Preparer's Company: T & R CHEMICALS, INC
Preparer's St Or P. O. Box: 700 CELUM ROAD
Preparer's City: CLINT
Preparer's State: TX
Preparer's Zip Code: 79836
MSDS Serial Number: BTBJB
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Ingredients/Identity Information
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Proprietary: NO
Ingredient: HYDROCHLORIC ACID, HYDROGEN CHLORIDE, MURIATIC ACID HYDROCHLORIDE
Ingredient Sequence Number: 01
Percent: 35.2
NIOSH (RTECS) Number: MW4025000
CAS Number: 7647-01-0
OSHA PEL: 5 PPM
ACGIH TLV: C 11 MG/CUM
Other Recommended Limit: 7 PPM
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Physical/Chemical Characteristics
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Appearance And Odor: CLEAR LIQUID, COLORLESS TO PALE YELLOW, PUNGENT, IRRITATING ACIDIC ODOR
Vapor Pressure (MM Hg/70 F): 30
Specific Gravity: 1.18
Solubility In Water: COMPLETE

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Fire and Explosion Hazard Data
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Flash Point: NONE
Special Fire Fighting Proc: WEAR SELF-CONTAINED BREATHING APPARATUS & FULL PROTECTIVE CLOTHING. USE WATER SPRAY TO COOL NEARBY CONTAINERS/ STRUCTURES EXPOSED TO FIRE.
Unusual Fire And Expl Hazrds: FLAMMABLE GAS (HYDROGEN) WILL BE LIBERATED FROM CONTACT W/SOME METALS.
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Reactivity Data
==========
Stability: YES
Materials To Avoid: ALKALIS/OXIDIZING OR REDUCING MATERIALS/CYANIDES/ SULFIDES/COMBUSTIBLE MATERIALS/METALS/METAL OXIDES/AMINES/VINYL ACETATE
Hazardous Decomp Products: HYDROGEN & CHLORINE UNDER CERTAIN OXIDIZING OR REDUCING CONDITIONS
Hazardous Poly Occur: NO
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Health Hazard Data
==========
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: INHALATION: VAPORS/MISTS ARE EXTREMELY CORROSIVE TO NOSE, THROAT & MUCOUS MEMBRANES; MAY BE FATAL. EYES: EXTREMELY CORROSIVE. SKIN: SEVERE BURNS, DERMATITIS; FATAL W/DEATH IF LARGE AREAS EFFECTED, DESTROY SURROUNDING TISSUE. INGESTION: EXTREMELY CORROSIVE TO MOUTH & THROAT W/BURNS, SEVERE ABDOMINAL PAIN; MAY BE FATAL.
CARCINOGENICITY - NTP: NO
CARCINOGENICITY - IARC: NO
CARCINOGENICITY - OSHA: NO
Explanation CARCINOGENICITY: NONE
Signs/Symptoms Of Overexp: INHALATION: IRRITATION, COUGHING, CHEST PAIN, BREATHING DIFFICULTY. INGESTION: VOMITING, NAUSEA, COLLAPSE; MAY CAUSE DEATH.
Med Cond Aggravated By Exp: RESPIRATORY ILLNESS W/ATTENDANT TISSUE DAMAGE & DESTRUCTION
Emergency/First Aid Proc: EYES: FLUSH W/PLENTY OF WATER FOR AT LEAST 30 MINS. SKIN: FLUSH W/PLENTY OF WATER. INHALATION: REMOVE TO FRESH. IF BREATHING STOPS, GIVE ARTIFICIAL RESPIRATION. INGESTION: DON'T INDUCE VOMITING. IF CONSCIOUS, GIVE PLENTY OF WATER. IF UNCONSCIOUS, DON'T GIVE ANYTHING BY MOUTH. OBTAIN MEDICAL ATTENTION IN ALL CASES.
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Precautions for Safe Handling and Use
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Steps If Matl Released/Spill: WEAR ACID-RESISTANT PROTECTIVE CLOTHING & SCBA. NEUTRALIZE. SMALL: EFFECTIVE MOP-UPS W/DISPOSAL OF WASTES IN DOT APPROVED WASTE CONTAINERS AFTER LIME OR SODA ASH NEUTRALIZATIONS HAVE BEEN MADE ARE ACCEPTABLE.
Neutralizing Agent: LIME OR SODA ASH
Waste Disposal Method: DISPOSE OF WASTE IN ACCORDANCE W/FEDERAL, STATE & LOCAL REGULATIONS.
Precautions-Handling/Storing: STORE IN COOL, DRY, WELL-VENTILATED PLACE.
KEEP CONTAINERS TIGHTLY CLOSED WHEN NOT IN USE & CHECK PERIODICALLY FOR ANY ESCAPED MATERIAL.
Other Precautions: DON'T APPLY PRESSURE TO REMOVE CONTENTS FROM ANY CONTAINER.

DON'T CUT, GRIND, WELD OR DRILL ON OR NEAR CONTAINERS OF ACIDS. EMPLOY STANDARD SAFETY PRACTICES APPLIED WHEN AROUND ACIDIC MATERIALS.
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Control Measures
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Respiratory Protection: NIOSH APPROVED RESPIRATOR FOR VAPOR/MIST CONCENTRATION AT POINT OF USE; FULL FACEPIECE OR HALF MASK AIR-PURIFYING CARTRIDGE RESPIRATOR EQUIPPED FOR ACID GASES/MISTS, SCBA IN PRESSURE DEMAND MODE, OR SUPPLIED-AIR RESPIRATORS
Ventilation: REQUIRED
Protective Gloves: ACID-RESISTANT RUBBER
Eye Protection: CHEMICAL GOGGLES & FULL FACE SHIELD
Other Protective Equipment: ACID-RESISTANT RUBBER SLICKER SUIT W/RUBBER APRON BOOTS W/PANTS OUTSIDE & RUBBER GLOVES W/GAUNTLETS
Work Hygienic Practices: REMOVE/LAUNDER CONTAMINATED CLOTHING/SHOES BEFORE REUSE. WASH THOROUGHLY AFTER HANDLING.
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Transportation Data
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Disposal Data
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Label Data
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Label Required: YES
Technical Review Date: 14FEB94
Label Date: 10FEB94
Label Status: F
Common Name: MURIATIC ACID
Chronic Hazard: YES
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Severe: X
Fire Hazard-None: X
Reactivity Hazard-Slight: X
Special Hazard Precautions: INHALATION: VAPORS/MISTS ARE EXTREMELY CORROSIVE TO NOSE, THROAT & MUCOUS MEMBRANES; MAY BE FATAL. EYES: EXTREMELY CORROSIVE. SKIN: SEVERE BURNS, DERMATITIS; FATAL W/DEATH IF LARGE AREAS EFFECTED, DESTROY SURROUNDING TISSUE. INGESTION: EXTREMELY CORROSIVE TO RESPIRATORY & DIGESTIVE TRACTS, EYES, SKIN.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: T & R CHEMICALS, INC
Label Street: 700 CELUM ROAD
Label P.O. Box: 330
Label City: CLINT
Label State: TX
Label Zip Code: 79836
Label Country: US
Label Emergency Number: 915-851-2761
Year Procured: UNK
==========